THE GEOLOGY OF THE PERMO-CARBONIFEROUS SYSTEM IN THE GLENDONBROOK DISTRICT, NEAR SINGLETON, N.S.W.

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(Plate xiv., and four text-figures.)

The district treated of in this paper, lies from 5 to 15 miles E. by N. from Singleton. It contains two units of Permo-Carboniferous rocks, namely, a small basin about 2 miles N.E. of Mt. Tangorin, with a diameter of approximately 3 miles; and the northward extension, from the Hunter River District, of the Upper Coal-Measures and Upper Marine Series along Glendon Brook and Westbrook Creek.

Previous Literature.—In his memoir on "The Geology of the Hunter River Coal Measures," Professor David* has described the outcrop of rocks belonging to the Lower Marine Series and Greta Coal-Measures in Parishes of Tangorin and Stanhope, and has indicated some of the outcrops on a sketch-map.

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* Mem. Geol. Surv. N. S. Wales, Geology, No.4, 1907, pp.188-189.

The Coal-Measures at Westbrook Creek were reported on by the late C. S. Wilkinson,* and also have been examined by Professor David.†

The ironstone at Westbrook Creek has also been mentioned in J. B. Jaquet's memoir on "The Iron-Ore Deposits of New South Wales."‡

Physiography, etc.—The knot of hills round Mt. Tangorin is composed of hard resistant rocks, mostly eruptive, of Carboniferous age. Similar rocks are also responsible for the range which trends about E.N.E. from Tangorin, although they do not form the summit of the range at all points. A part of the top of the range, for a distance of about 2 miles E.N.E., from portion 96, Parish of Stanhope, is made up of massive conglomerates and sandstones of Upper Marine age. These sandstones and conglomerates extend northwards nearly to the southern boundary of portion 90, Parish of Tangorin, and form a number of flat-topped hills. Less resistant rocks (of Lower Marine age) intervene between these conglomerates and sandstones and the Carboniferous rocks, and the denudation of these is responsible for the gap in the range at Cranky Corner. To the west of Brook's Mountain, the country becomes undulating. The rocks in this part belong to the Upper Coal-Measures and Upper Marine Series, which have been let down to the level of the Carboniferous rocks by heavy faulting.

A point worthy of note is the salinity of the creek-waters in the neighbourhood of the Tangorin Range. This is brought to one's notice, during dry weather, by the fact that the gravels and creek-beds are often covered with a white saliferous deposit, when there has been a good deal of evaporation.

General Geology.—Stratigraphically, the rocks represent two systems, (A) Carboniferous, and (B) Permo-Carboniferous.

(A) CARBONIFEROUS.—There are two distinct divisions of the Carboniferous rocks, separated from one another by the Webber's Creek fault, which extends in a general E.-W. direction for about 10 miles, and throws to the south.

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* Ann. Report Dept. Mines N. S. Wales, 1884, p.151.

† *Op. cit.*, pp.274-277.

‡ Mem. Geol. Survey N. S. Wales, Geology, No.2, 1901, p.111.

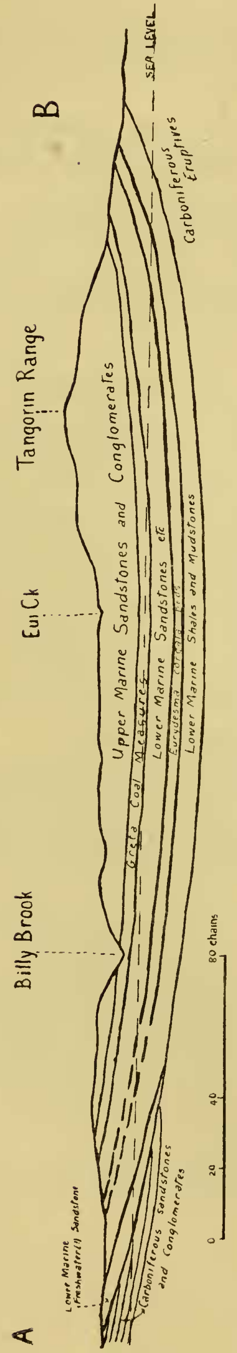
A
Billy Brook
Eui Ck
Tangorin Range
B
SEA LEVEL
Upper Marine Sandstones and Conglomerates
Greta Coal Measures
Lower Marine Sandstones etc
Eurydesma cordata beds
Lower Marine Shales and Mudstones
Carboniferous Eruptives
Lower Marine (Freshwater(?)) Sandstone
Carboniferous Sandstones and Conglomerates
0
20
40
80 chains

Fig. 1.—Section along AB.

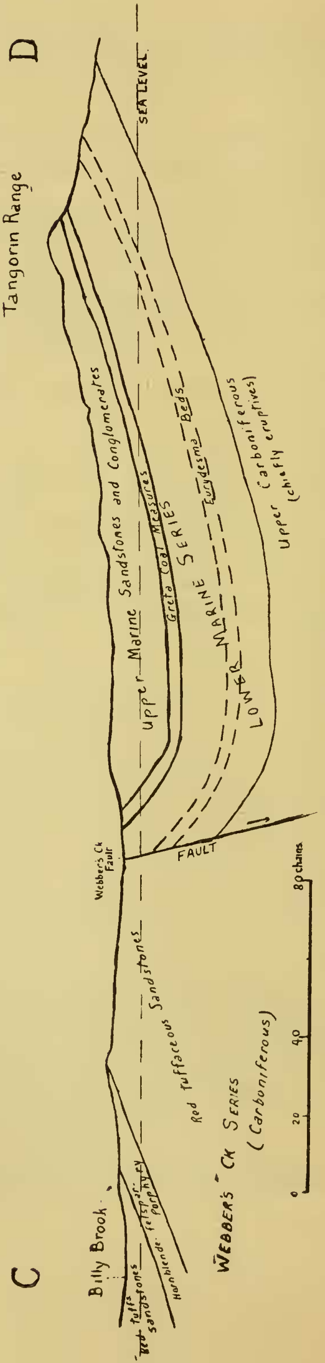
C
Billy Brook
Tangorin Range
D
SEA LEVEL
Upper Marine Sandstones and Conglomerates
Greta Coal Measures
Eurydesma Beds
LOWER MARINE SERIES
Upper (Carboniferous (chiefly eruptives)
Webber's Ck Fault
FAULT
Red tuffs sandstones
Hornblende-felspar-porphyry
Red tuffaceous Sandstones
WEBBER'S CK SERIES (Carboniferous)
0
20
40
80 chains

Fig. 2.—Section along CD.

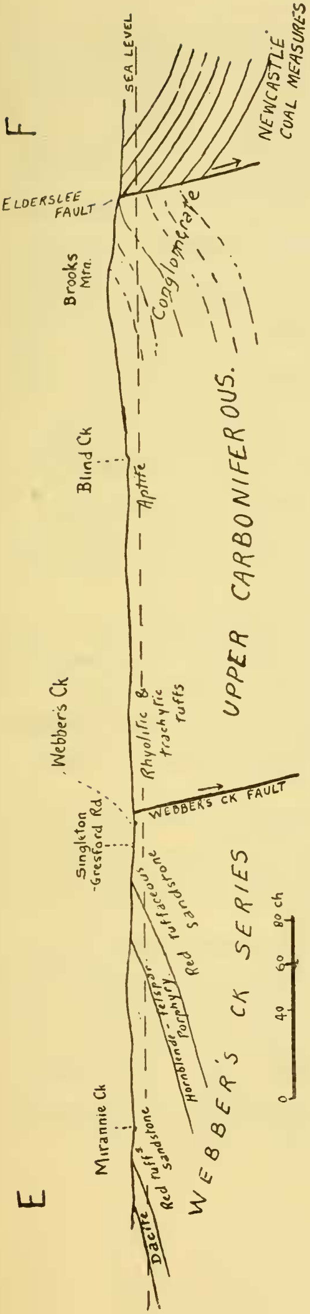

Fig.3.—Section along EF.

The older of these two divisions, that on the northern side of the fault, I have called here the Webber's Creek Series. This series has been examined, at intervals, for about a distance of 10 miles in an E.-W. direction, and extends for quite 5 miles north from the fault, which forms its southern boundary. The series consists of sandstones and shales, with contemporaneous lava-flows. The sandstones are more of the nature of arkoses, being composed mostly of grains of orthoclase with a smaller amount of quartz, hornblende, and biotite. In places, in these arkose sandstones, there are small bands of chocolate shale. The sandstones are conglomeratic in places, and, where this is the case, they contain pebbles of such rocks as banded rhyolite, andesite, aplitic granite, porphyrite, quartzite, etc. The lava-flows associated with this series consist of dacite and hornblende-felspar porphyry. There does not seem to be any doubt but that these flows are contemporaneous and not intrusive, although no very definite evidence is forthcoming on that point. They form long, comparatively narrow outcrops, roughly parallel to the strike of the arkose sandstones, and, being harder than the latter, they form lines of hills running in a general E.-W. direction. These hills have a relatively steep slope on the southern side, and slope more gently away to the north, showing that they dip to the north in the same way as the sedimentaries do.

This series of rocks appears to be similar to part of the Upper Carboniferous Series described, some distance further to the east, by Mr. J. B. Jaquet. Part of his description of the latter series is: "The formation comprises sandstones, claystones, limestones, tuffs, cherty shales, and intercalated lava-beds. The sedimentary rocks are in part marine, and in part freshwater. *The great bulk of the rocks consist of coarse-grained tuffaceous sandstones, which do not contain recognisable organic remains; so that one is unable to determine whether they are marine or freshwater.*"*

The latter part of this description might be applied equally well to the series under consideration here. I have not seen specimens of the Clarencetown Series, but in discussing the subject with Professor David, he pointed out the great similarity, lithologically, between specimens of the Webber's Creek Series and the Upper Carboniferous rocks near Clarencetown.

Another point which emphasises the resemblance to the Clarencetown Series is the fact, mentioned to me by Mr. Frank Drinan, of Glendon Brook, that, in the creeks in the north-eastern part of the area shown on the accompanying map, the sands which accumulate in the beds of the creeks often contain a notable percentage of ironstone.

No fossils have been found in this series, so that it is uncertain whether they are marine or freshwater. If, however, as seems to be the case, they belong to the same series as the Clarencetown rocks, they are probably freshwater.

The other series of Carboniferous rocks is developed to the south of the Webber's Creek fault, and is called here the Tangorin Series, on account of the bold outcrop at Tangorin Trig. Station. They are bounded on the west by the northward extension of the fault named, by Professor David, the Elderslee Fault. They extend as far east as the district has been examined, and no doubt are continuous with the Carboniferous series at Hudson's Peak. They surround, almost completely, the isolated basin of Permo-Carboniferous rocks at Cranky Corner. They consist of a varied series of eruptives—rhyolite, trachyte, dacite, andesite, pitchstone, etc., and also rhyolitic and trachytic tuffs, tuffaceous sandstones and conglomerates. Professor David has found an abundance of *Rhacopteris* in some of the tuffs on the road just south of Cranky Corner, so that there is no doubt that they belong to the same series (Upper Carboniferous) as those Carboniferous rocks occurring further south, at Winder's Hill and Pokolbin.*

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* *Op. cit.*, p.64.

No boundaries of these Carboniferous rocks have been surveyed, except where they are in contact with rocks of different age, but field-names have been placed on the map at points where they have been observed.

(B) PERMO-CARBONIFEROUS.—There are two separate occurrences of Permo-Carboniferous rocks in the district, namely, (*a*) the Cranky Corner Basin, (*b*) the series west of the Elderslee fault.

(*a*) *The Cranky Corner Basin.*—In this area, there is a development of some 1,850 feet of Permo-Carboniferous strata, made up approximately of 900 feet of Lower Marine Series, 150 feet of Greta Coal-Measures, and 800 feet of Upper Marine Series. An examination of the dips at once shows that these strata form a somewhat triangular-shaped basin. They are surrounded, for the greater part, by the Tangorin Series, except on a portion of their northern side, where they have been brought into contact with the Webber's Creek Series by the Webber's Creek fault. They are unconformable above the Carboniferous System, there being differences generally of 30° to 40° in the directions of strike, where Carboniferous and Permo-Carboniferous sedimentary rocks occur close together. Near portions 14 and 11, Parish of Stanhope, the Carboniferous conglomerates strike about N.-S., and dip easterly; while the Permo-Carboniferous rocks strike 327°, and dip at 14° in direction 57°. Near Tamby Creek, about portion 98, Parish of Tangorin, the Carboniferous conglomerate strikes 140°, dipping south-westerly, and the Permo-Carboniferous rocks strike 100° dipping southerly.

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* Journ. Proc. Royal Soc. N. S. Wales, xlv., 1911, pp.379-408.

(i.) Lower Marine Series.—In portions 35 and 98, Parish of Tangorin, just opposite portion 81, there is a small outcrop of rather coarse sandstone containing remains of plant-stems. This is resting unconformably on Carboniferous conglomerates, and is the lowest member of the Permo-Carboniferous System found in the district. The outcrop, however, is only of limited extent, being cut off by the Webber's Creek fault to the west, and thinning out between the Carboniferous conglomerates, and the overlying mudstones towards the south-east. From its lithological character, and from the presence in it of plant-stems, and also since it is the lowest member of the Lower Marine Series developed here, it seems very probable that it is to be correlated with the sandstone which is immediately above the glacial beds in the Lochinvar District. It attains a thickness of about 100 to 150 feet.

Next above this sandstone, there is a thickness of some 300 feet of bluish shaly mudstones. These can be traced, almost continuously, nearly right round the basin. About half-way up in these mudstones, there is an horizon of hard limestone-concretions containing fossils. These are chiefly *Fenestella*(?) sp., and a small brachiopod shell (? *Dielasma*). This bed with Fenestellidæ can be seen at three localities in the Parish of Stanhope, namely, (1) on the W.-E. road in portion 66, (2) in portion 46, and (3) in the creek in portion 50. The mudstones are fossiliferous, but most of the fossils appear to be in the upper part, *i.e.*, above the limestone-concretion horizon. Some of the fossils from these mudstones are:—

Spirifer duodecimcostata.
S. tasmaniensis.
S. stokesi.
Martiniopsis subradiata.
Chænomya sp.
Aviculopecten tenuicollis.
A. englehardti.
Pachydomus.
Ptycomphalina trifilata.
Hyolithes lanceolatus.

The best locality for collecting these, is in portion 10, Parish of Stanhope, on the western slope of the hill, between the creek and the eastern boundary of the portion.

In portion 91, Parish of Stanhope, there is a development of basalt and breccia in this series. This may represent a centre of volcanic activity, which was responsible for the tuffaceous nature of the sandstones next to be described.

Following the mudstones, there is a thickness of about 120 feet of rather coarse tuffaceous sandstone. Good outcrops occur, the best being those in portions 8, 96, 78, 76, and 74, Parish of Stanhope. It is thus seen that this sandstone occurs continuously on the western and south-eastern sides of the basin, but has not been observed to outcrop on the northern side. This absence on the northern side is due to the presence of the Webber's Creek fault. The sandstone contains numerous marine fossils, there being, in places, regular banks of such thick-shelled molluscs as *Eurydesma cordata, Platyschisma,* etc., indicating turbulent, shallow-water conditions during the deposition of the beds. The fossils present in this sandstone include—

Spirifer duodecimcostata.
S. tasmaniensis.
Martiniopsis subradiata.
Aviculopecten mitchelli.
A. tenuicollis.
Eurydesma cordata.
Pachydomus.
Scaldia(?).
Platyschisma oculus.
Mourlonia.
Ptycomphalina.
Hyolithes lanceolatus.

In appearance, this sandstone is sometimes very similar to that of Harper's Hill, and the similarity is increased by the occasional presence of andesitic boulders, with numerous amygdules of secondary silica, calcite, etc.

The remainder of the Lower Marine Series consists of about 330 feet of mudstones, sandstones, and conglomerates, in which fossils appear to be very scarce. At Eui Creek and Billy Brook, these are somewhat hardened and jointed, probably as a result of their proximity to the Webber's Creek fault.

(ii.) Greta Coal-Measures.—Above the Lower Marine Series, the Greta Coal-Measures are developed. They consist mostly of the sandstones and conglomerates typical of these measures, and there are also developed some beds of a brownish shale, as well as at least one coal-seam. The outcrop can be traced continuously round its northern part, from portion 41 to portion 29, Parish of Stanhope, but the remainder is somewhat less certain. However, in portions 70 and 96, Parish of Stanhope, there is a conglomerate not unlike the Greta conglomerate, associated with a soft brownish and yellowish sandstone containing indeterminate plant-remains, and it is not unreasonable to put these down as belonging to these measures, more especially as they occur at localities where one would expect to find the Greta Measures. In portion 42, Parish of Stanhope, there are some shaly beds which contain plant-leaves. Along the northern part of the outcrop, and where it is close to the Weber's Creek fault, the dips are considerably higher than they are a short distance to the east or west, where they are not so close to the fault-line.

Coal is developed in these measures, and actual outcrops can be seen in Kangaroo Creek, on portion 90, Parish of Tangorin, and also in Billy Brook, on portion 26, Parish of Stanhope.

At the Kangaroo Creek outcrop, Professor David has measured a section of the seam as follows*:—

Roof.	Conglomerate containing pebbles up to 3 or 4 inches in diameter.
0ft. 6in.	Hard bituminous coal.
1ft. 8in.	Clay shale.
0ft. 8in.	Carbonaceous sandstone.
0ft. 9in.	Hard bituminous coal.
0ft. 2in.	Band of pebbly sandstone.
1ft. 3in.	Hard bituminous coal.
0ft. 6in. to 1ft. 0in.	Band of fine conglomerate and sandstone, carbonaceous in places and clayey.
4ft. 0in.	Hard bituminous coal with pitchy lustre on freshly fractured surfaces. This coal approaches a cannel coal in composition.
0ft. 6in.	Coaly shale.
10ft. 0in.	Coal and bands.

Mr. Frank Drinan, of Glendon Brook, very kindly piloted me to the outcrop in Billy Brook. The position of this outcrop has been fixed fairly closely. It is in the bed of the creek, and the bearing from it to the western corner of portions 27 and 28, Parish of Stanhope, is $120\frac{1}{2}°$. The coal is uncovered there, in the creek, for about six feet, and Mr. Drinan assured me that the seam used to outcrop at a position he pointed out to me, but which is now covered with débris; this point is some 10 to 15 yards further downstream. As the seam is dipping about south at 16°, this would indicate (if the two points represent outcrops of the same seam) a thickness of approximately 11 to 13 feet of coal and bands. This thickness corresponds very well with that mentioned above, and the two outcrops (Kangaroo Creek and Billy Brook) are probably of the same seam. As this outcrop (Billy Brook) was under water at the time of my visit, it was not possible to obtain specimens suitable for analysis, but from the pieces which could be got, the coal appears to be a hard, bright, bituminous coal of good quality. The position and extent of the actual outcrops depend on weather-conditions a good deal. Between my two visits to Kangaroo Creek (about three months apart), there was considerable rain, and much of the outcrop, as first seen, was covered with soil washed down the creek-bank.

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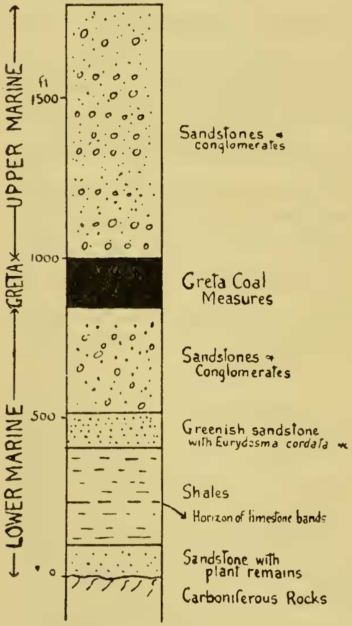
* *Op. cit.*, p.188.

At a number of other points in the neighbourhood, pieces of coal have been observed, washed into the creeks after heavy rains, *e.g.*, in Eui Creek above Mr. Peter's house, in portion 42, and in Billy Brook about portion 40, Parish of Stanhope. That these come from the same measures, there is no doubt, but the outcrops are probably covered over by surface-soil. The outcrop in Billy Brook is due to the creek having cut down through the overlying sandstone, isolating a part of it, and exposing the Greta Coal-Measures along the creek-bed. (See Section, Fig. 1, p. 148).

(iii.) The Upper Marine Series.—Above the Greta Coal-Measures, there is a series of massive sandstones and conglomerates. Marine fossils are very scarce in them, but, in the lower part, fragments of a Conularia (*C. inornata*) were found. These sandstones are, then, probably the equivalents of the lower part of the Branxton beds of the Upper Marine Series. The following is a vertical section of the Permo-Carboniferous rocks, as developed in this area (Fig. 4, p. 156).

(*b*) *Permo-Carboniferous Rocks west of the Elderslee Fault.*—The Elderslee fault, with a throw of nearly 6,000 feet to the west, brings the Upper Coal-Measures down against the Carboniferous rocks, just to the west of Brook's Mountain. In these Upper Coal-Measures, there are a number of coal-seams, which outcrop at intervals along Glendon Brook and Westbrook Creek. The series there consists chiefly of interbedded sandstones and conglomerates, with which there are also coal-seams, bands of ironstone, and occasional dolomitic bands. The ironstone is concretionary, and the bands vary from 1 inch to 15 inches in thickness. At the centre of the concretions, there is often a cavity in which quartz-crystals have grown. From the outcrops of the strata, Professor David* has calculated a descending vertical section, in which there are eighteen coal-seams varying from 3 to 27 feet in thickness. The measures in this part (Westbrook Creek), dip to the east, at angles up to about 70°, the very high angles of dip being at the extreme west of the occurrence of the series. The reason for these steep easterly dips is explained by their occurrence close to the Greta fault, which has a throw, at this point, of some 1,500 feet to the east, and forms the western boundary of these Upper Coal-Measures. Thus the Upper Coal-Measures here occupy an area of subsidence between two heavy faults, *i.e.*, it is a senkungsfeld-area. They do not extend any dis-



UPPER MARINE
GRETA
LOWER MARINE
ft
1500
1000
500
0
Sandstones & conglomerates
Greta Coal Measures
Sandstones & Conglomerates
Greenish sandstone with Eurydesma cordata *
Shales
Horizon of limestone bands
Sandstone with plant remains
Carboniferous Rocks

Fig. 4.—Vertical Section of the Permo-Carboniferous rocks.

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* *Op. cit.*, pp. 275-276.

tance to the north, the northern boundary being formed by the Webber's Creek fault. This is shown by the fact, that the great majority of the boulders in the gravels brought down by Westbrook Creek and its tributaries, consist of eruptive rocks (chiefly porphyries, and dark-coloured, fine-grained rocks) and tuffs. On the west of the Greta fault, the Upper Marine Series are found, and they extend away westwards, past Singleton, until they disappear under the Rix's Creek Coal-Measures.

Immediately next the fault, there are shaly and sandy mudstones, with numerous erratics. These dip towards the east, and belong to the Crinoidal Beds, being part of the eastern arm of the Belford anticline. Some of the erratics are quartzites containing fossils. To the north, these beds extend some considerable distance. I followed them along the Dyrring Road, to a point about 4 miles north of the village of Sedgefield.

Faulting.—In this area, there are three very heavy faults. Two of them are northward continuations of faults described by Professor David in the Hunter River District,* namely, the Greta and Elderslee faults, and, in each case, the throw has increased towards the northern end of the fault. The third has a roughly east-west trend, and throws to the south. It has been called here the Webber's Creek fault. The Greta fault has swung round from having a S.E.-N.W. trend to almost N.-S., and here has a throw of about 1,500 feet to the east, bringing the Upper Coal-Measures down into contact with the lower part of the Crinoidal Shales of the Upper Marine Series. The Elderslee fault strikes a little to the west of north, and has a throw of nearly 6,000 feet. The Carboniferous rocks, near the fault, are conglomerates, and rhyolitic and trachytic tuffs of Upper Carboniferous age, while, on the downthrow side, are rocks of the Upper Coal-Measures. At this point, then, all the rocks of the Lower Marine Series, Greta Coal-Measures, and Upper Marine Series that have been developed in the district, are faulted out of sight. That both the Lower Marine Series and Greta Coal-Measures were developed to some extent, is indicated by their presence at Cranky Corner, with a thickness of about 1,000 feet; the Upper Marine Series have practically their full development (4,800 feet) not far away, so it seems not unreasonable to put the throw of the fault somewhere in the neighbourhood of 5,800 feet. The Webber's Creek fault trends roughly E.-W. in its western extension, and swings round to a S.W.-N.E. trend towards its eastern end. It extends, on the map, from near Westbrook to near "The Gap," on the road from Singleton to Gresford. It is an extensive fault, and its existence is indicated mainly by the following points:—

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* *Op. cit.* pp.302-304.

(*a*) The southern boundary of the Webber's Creek Series is a fairly regular line, and that Series is in contact with beds of different ages at different points, namely, Upper Carboniferous at Tamby Creek, Permo-Carboniferous from Tamby Creek to One-Tree Hill, Carboniferous again from there to the Elderslee fault, and then Upper Coal-Measures at Westbrook Creek. The fact that all these different series are cut off on their northern side, in a fairly regular line, favours the existence of a fault.

(*b*) Where the Permo-Carboniferous rocks approach close to the Webber's Creek Series (at One-Tree Hill), they have very high dips to the south, while a short distance to the west, where they are not so close, the dip is much less.

(*c*) Also where the Permo-Carboniferous shales are nearest the Webber's Creek Series, there is a slight amount of metamorphism of the shales, which might easily have been the result of faulting.

(*d*) No tuffaceous sandstones, similar to the Webber's Creek Series, are found associated with the Carboniferous rocks, south of the line of junction of that series with the other series.

The Webber's Creek Series seems to be of the same age as similar rocks near Clarencetown, which Jaquet* has determined as Upper Carboniferous. The throw of the Webber's Creek fault is about equal to the amount of strata between these rocks and the top of the Carboniferous strata, but, as the exact position of these rocks in the Upper Carboniferous has not been determined, it is not possible, at present, to say what is the amount of the throw of this fault.

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* *Op. cit.*, p.62.

Summary.—Representatives of two Systems—Carboniferous and Permo-Carboniferous—occur in the district described. The Carboniferous rocks all belong to the Upper Carboniferous, some being of the same age as the Clarencetown tuffaceous sandstones, etc., and others of the same series as the rhyolites, etc., at Mount Bright, near Pokolbin. The boundary between the two Carboniferous series is formed by an extensive E.-W. fault (the Webber's Creek fault), throwing to the south.

The Permo-Carboniferous rocks occur in two separate areas. Just north-east of Mount Tangorin, there is a small, triangular-shaped basin made up of representatives of the Lower Marine Series, Greta Coal-Measures and Upper Marine Series. The most important point, economically, here is the occurrence of the Greta Coal-Measures. Previously it was thought that this was just the southern end of an extensive occurrence of the Coal-Measures, but the discovery that it is a small isolated basin, shows that there is probably no Greta coal anywhere to the north-east of the district, and on the north-west, the next occurrence is somewhere not far south-east of Muswellbrook. The small extent of the Cranky Corner basin, and its inaccessible position, make it improbable that it will ever be of any considerable economic value. The other area of Permo-Carboniferous rocks is just west of Brook's Mountain. Here the Upper Coal-Measures are developed, enclosed on three sides by heavy faults. Upper Marine Series (Crinoidal Beds) occur farther to the west, on the western side of the Greta fault.

My thanks are due to many of the residents of the district, who were always willing to assist me as far as possible, and, in particular, to Mr Frank Drinan, of Glendon Brook, and Mr. J. Graham, of Westbrook. I also wish to express my gratitude to Professor David and Mr. W. S. Dun for the interest they have taken in my work, and for the help they have rendered me, in discussing and criticising this work in preparation.

EXPLANATION OF PLATE XIV.

Geological Map of the Glendonbrook District.